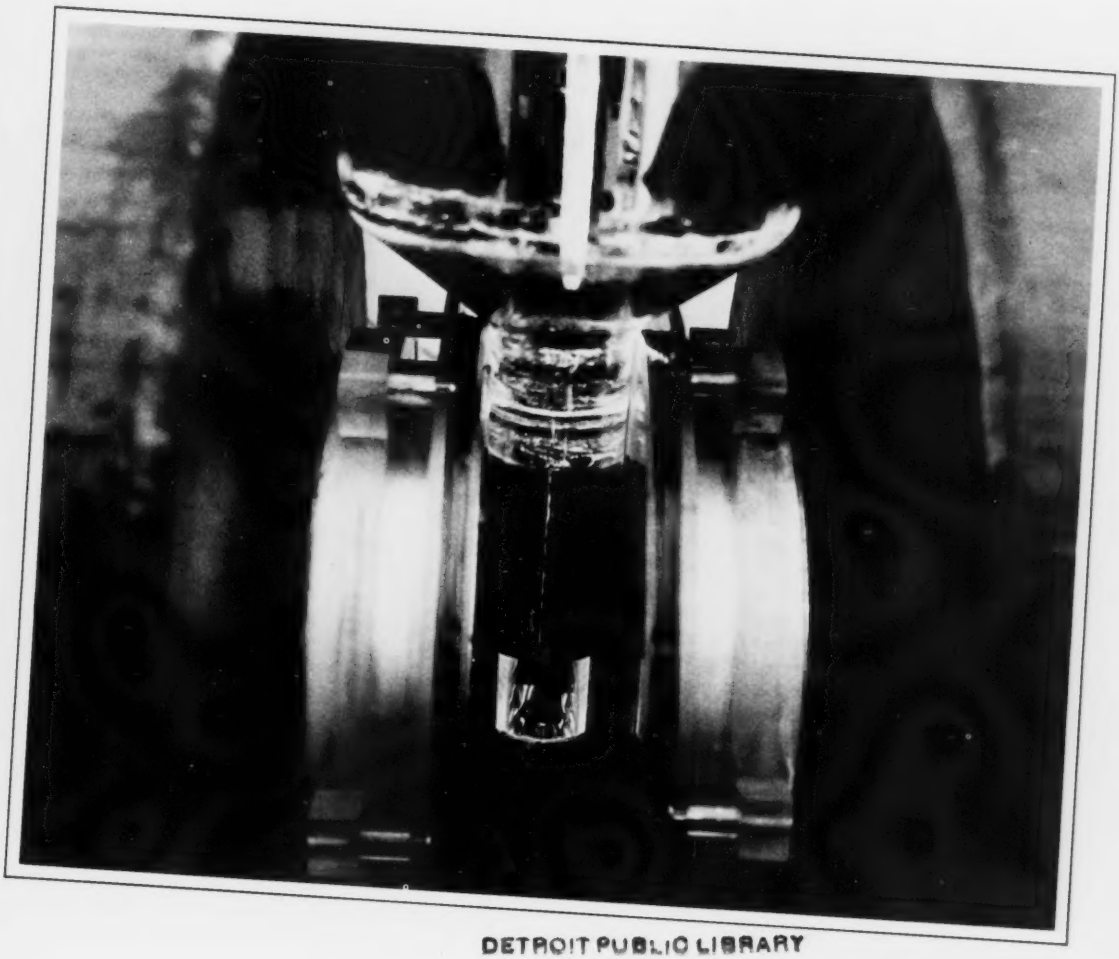
NATIONAL BUREAU OF STANDARDS

February/1969

Technical News Bulletin



U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

TNB Technical News Bulletin

FEBRUARY 1969/VOL. 53, No. 2/ISSUED MONTHLY

U.S. DEPARTMENT OF COMMERCE
Maurice H. Stans, Secretary

NATIONAL BUREAU OF STANDARDS
A. V. Astin, Director

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COVER: *This probe-dewar assembly hangs between poles of a large electromagnet. Visible through the window of the dewar is the resonance cavity of a newly designed sample probe used in exploring impurities and imperfections in crystalline materials.* *(See page 30.)*

Prepared by the NBS Office of Technical Information and Publications, Washington, D.C. 20234

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The National Bureau of Standards serves as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. For this purpose, the Bureau is organized as follows:

- The Institute for Basic Standards
- The Institute for Materials Research
- The Institute for Applied Technology
- Center for Radiation Research
- Center for Computer Sciences and Technology

The TECHNICAL NEWS BULLETIN is published to keep science and industry informed regarding the technical programs, accomplishments, and activities of NBS.

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Annual subscription: Domestic, $3; foreign, $4; single copy, 30 cents. Use of funds for printing this publication approved by the Director of the Bureau of the Budget (June 22, 1966).

Library of Congress Catalog Card Number: 25-26527

Thermodynamic Data Obtained on Oxygen

The outer adiabatic shield and the case surrounding a calorimeter are visible as R. D. Goodwin assembles the heat-capacity apparatus.

AT THE PRESENT TIME oxygen is used as the propellant oxidizer in the Saturn, Centaur, and Atlas rockets; it also finds application in fuel cells and environmental control systems for space capsules. Further applications, however, have been hindered by a lack of comprehensive and accurate data for many of its physical properties.

To supply data on oxygen for the U.S. space program, the NBS Institute for Basic Standards began a major program of basic research on its properties in 1965. Recently, R. D. Goodwin and L. A. Weber completed the latest phase of the program with heat-capacity measurements on gaseous and liquid oxygen from its triple point to room temperature, at pressures up to 350 atmospheres. This work, as well as a previous comprehensive compilation of accurate pressure-volume-temperature measurements[1] on oxygen, was sponsored by NASA.

The data from the heat-capacity experiments are being combined with the previously derived P-V-T values to produce tables of thermodynamic functions. These tables will include internal energy, entropy, enthalpy, and velocity of sound. Such tables are needed in modern missile and space engineering, where extreme accuracy is essential.

The heat capacity measurements were made with a calorimeter that was designed for earlier research on the specific heat of hydrogen. Its main component is a spherical sample-holder, approximately two inches in diameter, of type 316 stainless steel. A lightweight, cylindrical copper case protects an electric heater wound on the sphere. The case also provides the reference temperature for two thermopiles controlling an adiabatic shield.

The temperature of the sample holder was measured with a platinum resistance thermometer and a 6-dial microvolt potentiometer. The pressure measurements were made with a deadweight gage and are estimated to be accurate to about one part in 10 000.

The calorimetric heating rate was obtained from simultaneous readings of the heater potential and current. The time of the heating interval was measured by an electronic counter (quartz piezoelectric oscillator).

Results of the specific-heat research include a report of 86 experimental heat capacities for the two-phase system (liquid plus vapor) from the triple point to near the critical point, and corresponding derived values for the liquid phase only. The results also include 152 specific heats for the vapor and compressed liquid at temperatures up to 300 K and pressures up to 350 atmospheres. Accuracies of these values are estimated to be about 1 percent. In addition, a formula for the results was derived that can be integrated for heat absorption and for entropy changes.

[1] Oxygen data obtained for aerospace applications, NBS Tech. News Bull. 51, No. 12, 259–260 (Dec. 1967).

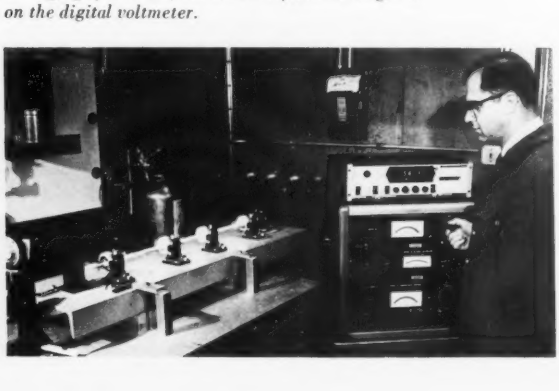
LASER-SOURCE REFLECTOMETER

For High-Temperature Reflectance Measurements

A KNOWLEDGE OF THE reflectance of refractory materials at high temperatures is required for the design of heat shields of reentry vehicles, nose cones of ballistic missiles, rocket nozzles, combustion chambers, leading edges of airfoils operating at supersonic velocities, and many other structures and parts for aerospace applications. In many cases, however, published values for the reflectance of refractory materials at high temperatures are of low precision and questionable accuracy. It is not at all unusual for reflectance values of what is reported as the same material at the same temperature to vary by as much as a factor of two.

Recently a significant increase in the precision and accuracy in the measurement of directional-hemispherical reflectance at high temperatures was made possible by the design and construction of a laser-source integrating sphere reflectometer.[1] This instrument was developed at the NBS Institute for Basic Standards by G. J. Kneissl and J. C. Richmond in work supported by the U.S. Air Force. It makes possible the measurement of the reflectance of specimens at temperatures up to 2000 K, with a precision on the order of 0.0035 in reflectance units, expressed as the standard deviation of six replicate measurements on the same specimen, and a constant error of measurement (bias) of less than one percent of the measured value. The accuracy attained is nearly independent of the geometric distribution of reflected flux (except for retroreflectors), and hence the method is particularly advantageous for studying the effect of surface finish on reflectance.

G. J. Kneissl obtains reflectance measurements from the laser-source reflectometer. The laser beam is alternately directed into a large integrating sphere (outside picture at left) and a small averaging sphere (left center). Reflectance is given on the digital voltmeter.



Operation

The NBS reflectometer consists essentially of (1) a continuous-wave helium-neon laser, used as the source, (2) a 35-cm diameter integrating sphere, which can be evacuated, (3) a specimen holder surrounded by an induction coil, in which the specimen is mounted in the sphere, (4) a detector, mounted on the sphere, which views a small area of the sphere wall, and associated equipment. The beam from the source is directed alternately, by means of a movable mirror, onto the specimen or the sphere wall. The ratio of the detector response when the laser beam is incident on the specimen to that when it is incident on the sphere wall is the directional-hemispherical reflectance of the specimen.

To correct for fluctuations in the laser output, the laser beam is chopped by a mirror chopper. When the mirror chopper blocks the beam, it is directed to a small averaging sphere equipped with a detector similar to that on the integrating sphere. The beam passed by the chopper is incident on the flip-flop mirror, which directs it onto the specimen or sphere wall. The outputs of the two detectors are separately amplified by identical synchronous amplifiers, and the signals from the amplifiers are fed to a ratioing multiplexer. The output of the multiplexer is a dc potential that is proportional to the ratio of the two input signals. It is displayed on a digital voltmeter. The ratio of this digital voltmeter reading when the laser beam is incident on the specimen to that when the beam is incident on the sphere wall is the reflectance of the specimen.

The samples are heated by induction. Electrically conducting specimens are held in a thoria crucible. Nonconducting specimens, such as metal oxides, are held in tungsten, graphite, or iridium susceptors. The susceptor is heated by induction, and heats the specimen by conduction and radiation.

The measurement of a small amount of reflected flux in the presence of a much larger amount of flux emitted by the hot specimen was a problem that had to be circumvented. A spike filter, transmitting only at the laser wavelength, was placed over the detector to eliminate most of the emitted flux. Synchronous amplification of the chopped reflected flux essentially eliminated the effect of the background flux transmitted by the filter.

Sphere Coating

The integrating sphere was coated with sodium chloride. Requirements for an integrating sphere coating are (1) that it be a near-perfect diffuse reflector of uniform reflectance, and (2) that it have high reflectance. In addition, the coating on this sphere had to withstand heating to high temperatures where it was close to the hot specimen, and to withstand repeated evacuation without damage and without excessive degassing. None of the commonly-used sphere coatings, such as magnesium oxide, barium sulfate, or sulfur, met all of these requirements. The sodium chloride coating proved to be satisfactory.

The sodium chloride was applied by spraying a suspension of fine crystals in ethyl alcohol. Successive thin coats were applied, each followed by drying in an oven at about 343 K, until the desired thickness of about 3 mm was attained.

Measurements were made in vacuum in order to prevent oxidation of the specimens. Pressures of less than 1×10^{-5} torr (1.33×10^{-3} N/m^2) were used at the lower temperatures, and the pressure did not exceed 1×10^{-4} torr (1.33×10^{-2} N/m^2) at the higher temperatures where volatilization of the specimen increased the pressure.

Accuracy of the laser source integrating sphere was estimated on the basis of a theoretical analysis, which indicated that the systematic error of measurement should not exceed one percent of the measured value. This estimate was confirmed experimentally by measurements on calibrated mirrors. Precision of the method averaged about 0.0035 reflectance unit for all specimens measured, but was on the order of 0.0005 reflectance unit for graphite. This is expressed as the standard deviation of repeated measurements on the same specimen at the same temperature.

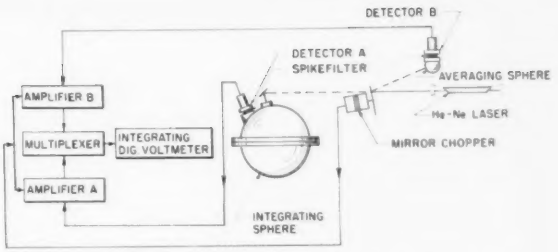


Diagram of the laser-source integrating sphere reflectometer.

[1] Kneissl, G. J., and Richmond, J. C., **A laser-source integrating sphere reflectometer**, NBS Tech. Note 439 (Feb. 1968), for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, 45 cents.

NBS and ESSA To Monitor Wind Effects on Buildings

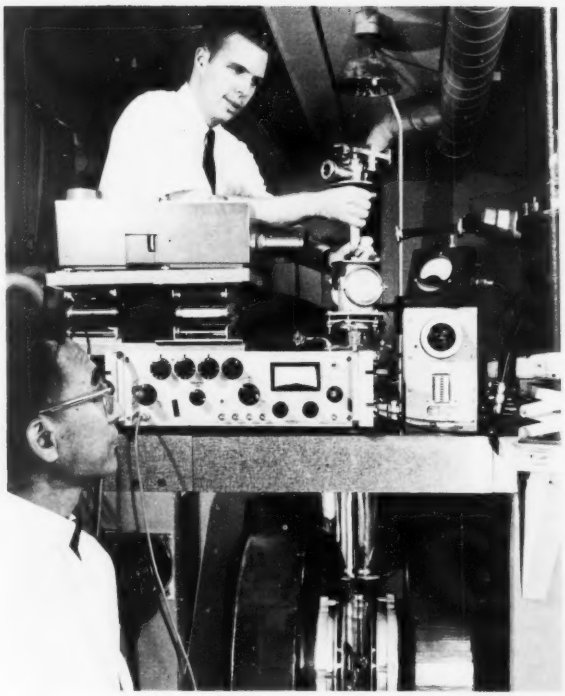
THE EFFECT OF WIND ON buildings is the subject of a study currently underway at the Institute for Applied Technology. This study, jointly sponsored by the Department of Commerce's Environmental Science Services Administration (ESSA) and NBS, is of special significance because of the recent trend toward lighter, more slender buildings and larger window panels. It is difficult to estimate the cost of overdesigning buildings against wind forces. However, U.S. Weather Bureau records indicate that the average yearly damage to structures by wind in the continental United States is approximately $600 million; for two years on record the damage exceeded $1 billion. Benefits resulting from increased economy and safety should far exceed the cost of the study.

H. C. S. Thom of ESSA's Environmental Data Services and R. D. Marshall of NBS are directing the study, which is aimed at improving the design techniques for structures exposed to wind. At present most building codes make some provision for loads due to wind. These codes, however, are largely based upon results of wind-tunnel studies in which the prototype conditions may have been incorrectly modeled. One of the primary goals of the study is to obtain accurate data from full-scale buildings that can be used to establish improved modeling techniques. The study will also provide more information on the nature of strong winds and on the aerodynamic interaction between the wind and buildings.

The building research facility on the NBS campus at Gaithersburg, Md., has been selected for the initial phase of the study. A number of pressure sensors will be installed in the building to indicate both steady and fluctuating pressures over the exterior walls. Simultaneous recordings of the oncoming wind will be obtained by mounting several fast-response anemometers on an array of five towers placed upwind of the building.

The test building is 100 x 380 ft in base dimension and 50 ft high. It is located in an area that affords a relatively clear exposure to prevailing winds. Although a building of these proportions is generally quite stable, even in extreme winds, the unique construction of this building will considerably reduce the cost of installing pressure sensors. Once the techniques associated with instrumentation, data acquisition, and data reduction are perfected, the study will focus on taller buildings where response of the structural frame to aerodynamic forces is of primary concern.

Thomas Ensign inserts the probe into a double dewar while Te-Tse Chang checks the extension of the probe through the dewar by means of an optical slit extending the length of the dewar. The sample portion of the assembly (below) is surrounded by a large electromagnet. At the left a monochromatic light source rests on jacks.



Versatile Probe

FOR OPTICAL-EPR STUDIES

A VERSATILE SAMPLE PROBE, recently developed at NBS, is proving quite useful in exploring impurities and imperfections in crystalline materials. Such studies are becoming increasingly important because most modern electronic devices are now "solid state," making use of organic or inorganic solids containing well-controlled traces of foreign ions or atoms. Included are such devices as (photo) diodes, transistors, lasers, photochromic materials, phosphors, and counters.

The present apparatus enables the investigator to measure electron paramagnetic resonance (EPR) spectra under a variety of experimental conditions—illumination, temperature, magnetic field, and applied frequency. The probe was designed [1] by T. C. Ensign, an NRC–NBS Postdoctoral Research Associate, and Te-Tse Chang, of the NBS Institute for Materials Research staff, under a program sponsored by the Advanced Research Projects Agency through Project Crystal Defect Studies on Laser Materials.

Probe Design

The probe is a pipelike device that can hold, in a varying temperature environment (room temperature down to below the temperature of liquid helium, 1.3 K), any crystalline or powdered material to be investigated. One of the probe's outstanding features is a rigid but adjustable coaxial coupling system (coaxial line) that physically and electrically connects the resonance "test" cavity at the lower end of the line to the microwave system at the upper end, with minimum energy losses and stray reflections.

In addition to the coaxial line, the probe consists of a microwave source, a microwave transition coupling system, a light pipe, an iris assembly, and a resonance cavity.

The upper end of the coaxial line is connected to the microwave system by a microwave transition. This transition is adjusted to obtain optimum electrical matching between the microwave system and the coaxial line, which carries the microwave radiation to the sample cavity. Optimum electrical matching can be obtained by adjusting the depth of the center conductor of the coaxial line protruding into the waveguide, enabling the standing wave ratio to closely approach unity. Then the lower end of the coaxial line is shorted by a piece of wire to form a current loop, which permits coupling with the cavity.

A light pipe, an electropolished stainless steel tube, surrounds the coaxial line. A light port extends perpendicular to the light pipe and can be used or closed off as desired. A rhodium-silver plated brass mirror surrounds the coaxial line at a 45 degree angle with the light pipe to the sample.

At the lower end of the coaxial line, the current loop makes optimum electrical matching (adjustable as was the transition coupling) with the iris assembly. Slits are

arranged in the circular base of the assembly to permit the light that is reflected down the light pipe to pass into the resonance cavity.

The probe is mounted within a double dewar for low-temperature measurements and is supported between the two poles of an electromagnet, which provides external field monitoring.

The probe has been tested with considerable success in experiments on a double-doped ZnS:Cu, Ga crystal. NBS data on the photon absorption lines of the crystal at various magnetic field strengths and microwave frequencies showed good agreement with results obtained on the same crystal by other scientists.[2]

Subsequently this probe was used to study photosensitive color centers in a single crystal of calcium oxide.[3] An EPR line width of 0.000 001 tesla was obtained, the narrowest line width ever observed in solid samples. The increase in the production of color centers responding to excited light, and the color centers' decay after the removal of the excited light, could be traced by the EPR signal monitor.

The completion of the light pipe makes possible a wide variety of optical-EPR studies on insulating crystals. Such studies should help clarify the nature of color centers, foreign ions, and the mutual interactions of these two. Once this has been done, long-hidden secrets of crystals hopefully would be revealed that would aid in improving the quality of lasers.

[1] Ensign, T. C., and Chang, T. T., **A low-temperature optical-EPR sample probe using tunable coaxial coupling,** Rev. Sci. Instr. (to be published).
[2] Fair, H. D., Jr., Ewing, R. D., and Williams, F. E., **Electron paramagnetic resonance of photoexcited donor-acceptor pairs in zinc-sulfide crystals,** Phys. Rev. Letters **15,** No. 8, 355–356 (Aug. 1965).
[3] Chang, T. T., Ensign, T. C., and Henderson, B., **Electron paramagnetic resonance studies of the F^+ center in CaO,** Am. Phys. Soc. Bull. **13,** No. 11, 1415 (Nov. 1968).

PIEZOELECTRIC PHENOMENA IN ELASTOMERS

Seymour Edelman assembles two disks of polystyrene into a test element, using silver paint as an adhesive and for electrical connections.

SOME ELASTOMERIC MATERIALS that are used for damping vibratory motion are also capable of weak piezoelectric response, although this capability has not yet been put to use. Recent studies at the Institute for Applied Technology show that this effect is greatly enhanced in some rubberlike materials by a process similar to that used to form electrets, and by the presence of a strong electric field.[1] The studies were conducted by physicist Seymour Edelman, of the Institute's instrumentation application laboratories, with the assistance of Steven Roth and Larry Grisham. Their methods increased the piezoresponse of some materials enough for application to be made of them.

The piezoelectric behavior of some long-chain polymers has received cursory mention in the literature, but the exploitation or systematic study of this behavior has not been reported to date. Rubberlike materials are among those used at the Bureau in experimental piezoelectric "shakers"—devices used for calibrating accelerometers—as passive damping material to reduce resonance peaks and thereby increase the shakers' useful frequency range. Layers of butyl rubber have been found to be useful for this purpose at frequencies below 50 kHz. Layers of piezoelectric ceramics were used at higher frequencies not only to damp passively but actively as well, being excited by a portion of the driving signal suitably shifted in phase.

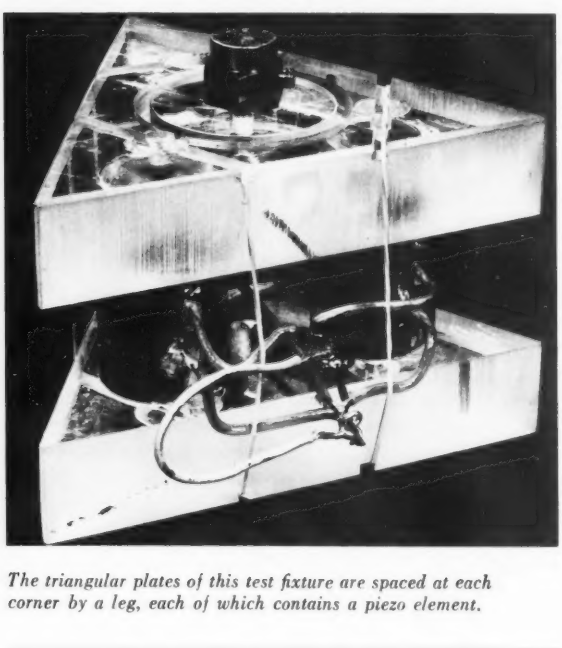
continued

PHENOMENA *continued*

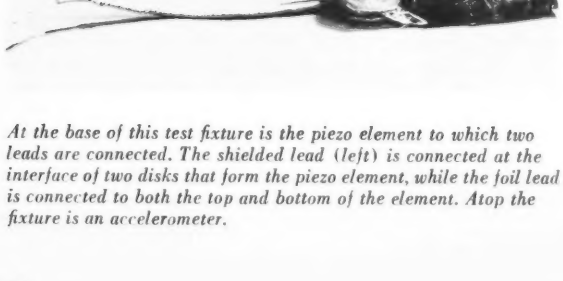
Although rubberlike materials at first thought would not seem to be firm enough to impart motion, the NBS team experimentally applied the driving signal to the elastomer layers as they had to the ceramic. They found, for some elastomers, a small but significant piezo effect, which they sought to improve.

Preparing Specimens

Following the reasoning that the piezoelectric response resulted in part from electret properties—electrical polarization analogous to permanent magnetization—the scientists experimentally treated their samples to maximize electret formation. They did this by reducing the viscosity of $\frac{1}{16}$-inch- to $\frac{1}{8}$-inch-thick sheets of the material and allowing it to resolidify in an intense electrical field. They first tried soaking the material in a volatile solvent, which was then allowed to evaporate from the specimen in the presence of as strong a field as could be applied without arcing, but this proved to be hazardous. Much better results were obtained by heating the material almost to the melting point and allowing it to cool while a voltage was placed across it by two electrodes connected to an adjustable dc power supply.



The triangular plates of this test fixture are spaced at each corner by a leg, each of which contains a piezo element.



At the base of this test fixture is the piezo element to which two leads are connected. The shielded lead (left) is connected at the interface of two disks that form the piezo element, while the foil lead is connected to both the top and bottom of the element. Atop the fixture is an accelerometer.

Testing Specimens

The piezoelectric properties were measured, in essence, by mounting elements made from the test material on a steel plate and attaching an accelerometer atop the element. The accelerometer output was monitored as the ac input was swept in frequency from 10 Hz to 10 kHz, both with and without a bias dc voltage of 2100–3150 V superimposed on the ac input. The ac input was set at 400 V in some cases; in all others the output was normalized to this value to make the results comparable. Under these conditions, piezoelectric activity manifests itself as an alternate thickening and thinning of the element, detectable by the accelerometer.

Findings

Not all of the materials tested showed piezoelectric properties, and in only some of the materials was the effect increased by the electret formation process. The alternate thickening-thinning of the element was most readily detected at resonance frequencies that are functions of the mass-spring characteristics of the vibrating system.

The activity of the samples increased linearly with increase in the bias and added linearly to the activity present without bias. Many of the samples vibrated at twice the applied frequency in the absence of biasing, a response that was caused by electrostriction. This can be thought of as attraction between unlike charges on opposing sides of the sample, which occurs twice for each cycle of excitation. The effect disappears with the application of a dc biasing voltage at least as great as the driving voltage (zero to peak).

The usefulness of the piezo effect in damping vibration was demonstrated in a test fixture using three test elements to support a triangular plastic plate. The plate was set into vibration by sound from a loudspeaker positioned above it and the motion was sensed by an accelerometer and displayed on an oscilloscope. Exciting the three elements from a single source modulated the signal shown on the oscilloscope. The frequency and amplitude of the modulating signal could be adjusted to nullify the loudspeaker-induced vibration.

[1] Edelman, S., Roth, S. C., and Grisham, L. R., **Electrical generation of motion in elastomers**, Bull. 39th Shock and Vibration Symp., Shock and Vibration Information Center, Naval Research Laboratory (in press).

New Definitions Authorized for SI Base Units

NEW ENGLISH-LANGUAGE DEFINITIONS of the base units of the International System of Units (abbreviated SI for Système International) are now available as a result of recent actions by the Advisory Committee on Units (Comité Consultatif des Unités, C.C.U.) of the International Committee of Weights and Measures. The new definitions are given below.

The International Committee of Weights and Measures makes technical proposals that are acted on by the General Conference of Weights and Measures, established under the Treaty of the Meter in 1875. These proposals originate in seven advisory committees, one of which is the Advisory Committee on Units.

At a meeting in 1967, the C.C.U. modified some of the definitions of the units on which the International System of Units is based. At the C.C.U. meeting it was agreed that "authorized" English translations of the official French definitions of the base units should be made available. In the authorized English translations [1] both British and American spellings of "gramme," "meter," etc., are equally recognized.

[1] Published in the report, Comité Consultatif des Unités, Session de 1967, Imprimerie Durand, 28–Luisant (France).

Définitions des unités de base du SI

mètre (m) Le mètre est la longueur égale à 1 650 763,73 longueurs d'onde dans le vide de la radiation correspondant à la transition entre les niveaux $2p_{10}$ et $5d_5$ de l'atome de krypton 86.
(11e *C.G.P.M.* (1960), *Résolution* 6)

kilogramme (kg) Le kilogramme est l'unité de masse; il est égal à la masse du prototype international du kilogramme.
(1re *et* 3e *C.G.P.M.*, 1889 *et* 1901)

seconde (s) La seconde est la durée de 9 192 631 770 périodes de la radiation correspondant à la transition entre les deux niveaux hyperfins de l'état fondamental de l'atome de césium 133.
(13e *C.G.P.M.* (1967), *Résolution* 1)

ampère (A) L'ampère est l'intensité d'un courant constant qui, maintenu dans deux conducteurs parallèles, rectilignes, de longueur infinie, de section circulaire négligeable et placés à une distance de 1 mètre l'un de l'autre dans le vide, produirait entre ces conducteurs une force égale à 2×10^{-7} newton par mètre de longueur.
(*C.I.P.M.* (1946), *Résolution* 2 *approuvée par la* 9e *C.G.P.M.*, 1948)

Note. L'expression «unite M.K.S. de force» qui figure dans le texte original a été remplacée ici par «newton» adopté par la 9e C.G.P.M.

kelvin (K) Le kelvin, unité de température thermodynamique, est la fraction 1/273,16 de la température thermodynamique du point triple de l'eau.
(13e *C.G.P.M.* (1967), *Résolution* 4)

candela (cd) La candela est l'intensité lumineuse, dans la direction perpendiculaire, d'une surface de 1/600 000 mètre carré d'un corps noir à la température de congélation du platine sous la pression de 101 325 newtons par mètre carré.
(13e *C.G.P.M.* (1967), *Résolution* 5)

Definitions of the base units of SI

(translated from French)

C.G.P.M.: Conference Générale des Poids et Mesures; General Conference of Weights and Measures.

C.I.P.M.: Comité International des Poids et Mesures; International Committee of Weights and Measures.

metre (m) The metre is the length equal to 1 650 763.73 wavelengths in vacuum of the radiation corresponding to the transition between the levels $2p_{10}$ and $5d_5$ of the krypton-86 atom.
(11*th* *C.G.P.M.* (1960), *Resolution* 6)

kilogramme (kg) The kilogramme is the unit of mass; it is equal to the mass of the international prototype of the kilogramme.
(1*st* *and* 3*rd* *C.G.P.M.*, 1889 *and* 1901)

second (s) The second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium-133 atom.
(13*th* *C.G.P.M.* (1967), *Resolution* 1)

ampere (A) The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 metre apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} newton per metre of length.
(*C.I.P.M.* (1946), *Resolution* 2 *approved by the* 9*th* *C.G.P.M.* 1948)

kelvin (K) The kelvin, unit of thermodynamic temperature, is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water.
(13*th* *C.G.P.M.* (1967), *Resolution* 4)

candela (cd) The candela is the luminous intensity, in the perpendicular direction, of a surface of 1/600 000 square metre of a black body at the temperature of freezing platinum under a pressure of 101 325 newtons per square metre.
(13*th* *C.G.P.M.* (1967), *Resolution* 5)

Note: The spellings "base unit," "metre," "kilogramme," "caesium," and "black body" have been used above, but "basic unit," "meter," "kilogram," "cesium," and "blackbody" are also used in some English speaking countries.

The Nation's two "time keepers"—the National Bureau of Standards, Boulder, Colo. (top) and the U.S. Naval Observatory, Washington, D.C.—recently synchronized their clocks to provide the country with a unified time system of unsurpassed accuracy.

NATION GETS Unified Time System

NBS and Naval Observatory Synchronize Time to About 1 Microsecond

A UNIFIED TIME SYSTEM of unsurpassed accuracy for the entire country was achieved recently when the Nation's two "time keepers"—the National Bureau of Standards and the U.S. Naval Observatory (USNO)—synchronized their clocks. On October 1, 1968, these agencies cooperated to effect a much more precisely coordinated time system than has ever before existed. The action taken by these agencies was the synchronization of their Coordinated Universal Time (UTC) clocks to within about 1 microsecond of each other. Synchronization was achieved when the NBS Time and Frequency Division (Boulder, Colo.) increased the rate of its UTC(NBS) clock by 4 parts in 10^{13}, while the Naval Observatory (Washington, D.C.) decreased the rate of its UTC(USNO) clock by 4 parts in 10^{13}.

The Bureau and the USNO have been cooperating under regulations of the International Radio Consultative Committee (CCIR), which for the past several years has required synchronization of standard time broadcasts to one thousandth of a second. This has been adequate for most users, but as technology has advanced, many precise timing needs have developed that cannot be met by this tolerance. More than a year ago, the desirability of synchronizing the USNO and NBS frequency and time standards to much finer tolerances than 1 millisecond was recognized.

In anticipation of a coordinated coordinate rate for USNO and NBS, on August 24, 1967, the Coordinated Universal Time clock of the Bureau, UTC(NBS), and all UTC transmissions of NBS were advanced by 200 microseconds. This left NBS about 35 microseconds early relative to USNO.

As the rate of the USNO clock has been high relative to the NBS clock by about 1 part in 10^{12}, the two clocks drifted toward each other. Their time lines converged on about October 1, 1968, and the time difference between the USNO clock, UTC(USNO), and the NBS clock, UTC (NBS), became zero. At that time USNO reduced the rate of its clock by 4 parts in 10^{13}, and NBS increased the rate of its clocks controlling NBS standard transmissions by 4 parts in 10^{13}. (A clock running fast by 4 parts in 10^{13} accumulates about 35 billionths of a second error per day. This rate of error would require about 80 000 years to accumulate one second in error.) The present specified absolute accuracy of the rate of the NBS clock is ± 5 parts in 10^{12}.

Measurements made after October 1 with portable clocks indicate that the time difference between the USNO and the NBS coordinated clocks is within one microsecond. By mutual agreements between USNO and NBS, small frequency adjustments ($<10^{-12}$) will be made infrequently to assure that this time difference remains less than about three microseconds.

Among scientists requiring more precise time measurements are geodesists, who, in attempting to measure the Earth very accurately, must sight on an artificial satellite from distant locations at very nearly the same instant of time. The sightings must be made within about 100 microseconds of each other, but the geodesists would prefer that the time error be within 10 microseconds. There are also military and NASA requirements that require synchronization accuracies in the microsecond range. It should be emphasized that this is synchronization accuracy and not absolute time-of-day accuracy.

Meanwhile, there is a general trend in technology toward tighter tolerances on synchronization. For example, the planned Aircraft Collision Avoidance System (ACAS) specifies worldwide synchronization accuracy of 0.5 microsecond, which is possibly beyond the current state-of-the-art.

To meet such needs, the National Bureau of Standards and U.S. Naval Observatory are engaged in a joint effort to provide a unified time service to all the United States. The new system is near the limit of the present state-of-the-art in its ability to provide accurate time and time synchronization to remote locations. This synchronization system is expected to provide a working model of a coordinate time system suitable for extension to worldwide coverage at some later date.

TECHNIQUE DEVELOPED FOR MATRIX-ISOLATION SPECTROSCOPY

THE MATRIX-ISOLATION TECHNIQUE for obtaining spectra has proved useful for studies of both high-temperature species and species of marginal stability. Spectral studies of metal atoms trapped in an inert gas, for example, provide valuable data on the effect of a matrix on autoionizing and atomic transitions. In the technique generally used, the metal atoms are heated in a furnace and allowed to effuse onto a cold (15 K) window simultaneously with an inert gas. The experimental difficulties of this method, however, increase with the temperature required in the furnace.

In an effort to more fully utilize the matrix-isolation technique, J. S. Shirk* and A. M. Bass of the Institute for Basic Standards recently developed an alternate method for isolating high-melting materials for spectroscopic study.[1] In this work, which was sponsored by the National Aeronautics and Space Administration, the process of dislodging metal atoms from the bulk sample was accomplished by using excited products from a microwave discharge to bombard the metal sample.

With this method, spectra of atomic copper and iron in xenon, krypton, and argon have been obtained. In addition, silver spectra have been obtained in xenon and argon. Cadmium isolated in xenon was another combination especially chosen so as to compare the NBS-obtained spectra with spectra obtained in recent work using the furnace method.[2] The results of this comparison have verified the applicability of the microwave dislodgement technique for matrix-isolation spectroscopic studies.

The spectra of silicon monoxide trapped in xenon, krypton, and argon were also observed. In a comparison with spectra obtained from this species in the gaseous phase, the observed bands agreed quite well, except for a constant matrix shift.

In the NBS study, spectra were obtained by using an evacuable scanning monochromator. The instrument had a dispersion at the exit slit of 10 Å/mm. The region from 1600–6000 Å was scanned using a molecular hydrogen continuum lamp (1600–3500 Å) and a tungsten-filament lamp (3500–6000 Å) as sources, and a photomultiplier detector having a fused silica window.

The sample was fashioned into a grid. The discharged gas was then passed over the metal sample and was condensed onto a lithium fluoride window at 15 K.

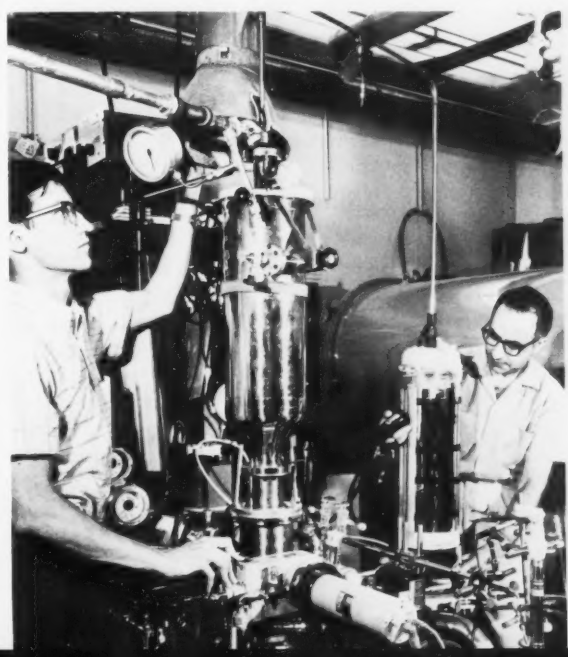
It was found in the study that if a positive potential was applied to the metal sample, no spectra of metal atoms were observed. This indicated that positive ion bombardment was the principal mechanism for atom production.

This mechanism for atom production is similar to the well-known sputtering process. However, the new technique uses low-energy ions in contrast to the usual sputtering process in which positive ions are accelerated, usually to several keV, and allowed to bombard solid metals. The process is widely used for the deposition of thin metal films.

The NBS-developed technique was found to be an effective alternative to a furnace for production of metals for matrix isolation studies. In addition, the study showed that reactive sputtering (a process whereby the sputtering ions react with the metal being sputtered) is a means for the preparation and isolation of otherwise unstable metal compounds. The new technique is also a potential source of important data on sputtering at low energies. As discharges are used in a wide variety of experiments, it is also important to recognize that low-energy sputtering may cause unwanted interference when discharges are used in conjunction with metal systems.

[1] Shirk, J. S., and Bass, A. M., Matrix isolation spectra of discharge "sputtered" metals, J. Chem. Phys. (to be published).
[2] Duley, W. W., Proc. Phys. Soc. **91**, 976 (1967).

J. S. Shirk (left) prepares apparatus for matrix-isolation studies, while A. M. Bass transfers liquid hydrogen to the cryostat.



*NRC–NBS Postdoctoral Research Associate, 1967–1969.

Robert Christian holds "Sandy Bagg," as Earl Cooke belts Sandy in place on the sled of the NBS dynamic testing machine. Sandy is one of the contenders for the "standard dummy" for dynamic testing of automobile occupant restraint systems.

DUMMIES EVALUATED FOR Seatbelt Testing

STUDIES OF AUTOMOBILE occupant restraint systems—seatbelts and their anchorages, for instance—at the NBS Office of Vehicle Systems Research have, like similar studies elsewhere, used dummy occupants in simulated crashes. In this research for the National Highway Safety Bureau (Department of Transportation), OVSR engineers have found that none of the dummies tested react in simulated crashes as do humans. In fact, the engineers found, with the assistance of the U.S. Air Force, that no two types of dummies stress the restraint system equally. This result is apparently due to differences in articulation and ways in which the human occupant braces himself for the deceleration. NBS is empirically determining correction factors for use with dummies and is developing specifications for sturdy and inexpensive dummies for testing restraint system performance.

Occupant Restraint Systems Studies

NBS work on motor vehicle occupant restraint systems, under Richard W. Armstrong of the OVSR staff, deals with the safety performance of the system as well as an evaluation of its components, such as the seat, seatbelt and shoulder harness assemblies, and anchorages. Component evaluation is concerned with tests to determine deflection characteristics of seats; webbing properties such as strength, elongation, abrasion resistance, and degradation by exposure to light; proper operation of buckles; and strength and corrosion resistance of anchorages.

The safety performance of the restraint system is appraised on a sled which is accelerated and decelerated on a track to simulate an automotive collision. This dynamic test machine developed by NBS engineers is now used, with dummies as occupants, in testing seatbelts and shoulder harnesses. Its instrumentation records displacements imparted to the dummy, as well as forces imposed on the webbing, and the anchorages. However, this does not tell us if the response of the dummies is sufficiently like that of human subjects under impact conditions. A comparison of dummies with humans was required to justify the use of the dummies.

Tests on the Daisy Decelerator

NBS carried out a series of tests using human subjects on the Daisy Decelerator, a sled-and-track device at Holloman Air Force Base, N. Mex., in 1967. High-speed film recorded the body movements of 23 volunteers subjected to decelerations ranging from 8 to 16 g. Physiological responses, sled velocity and deceleration, and displacement and loading of belt and shoulder harnesses were recorded.

During this series of tests, measurements were also made of the total belt and harness load for dummies on a sled subjected to the same impact pulse. In addition, the dummies were subjected to a 30-*g* deceleration, which is considered to be near the upper tolerance level for humans restrained by seatbelts. A half-sine wave deceleration impact pulse was used (because this most closely simulates an actual car crash), the sled reaching a velocity of 40 feet per second with a stopping distance of 19 inches. The total loadings for dummies and humans were compared. A value for humans for 30 *g* was estimated from the values for 8-, 12-, and 16-*g* runs.

It was apparent that other factors besides the mass of the dummy and the test deceleration determine the loading imparted to the restraint system and, moreover, that dummy response is not equivalent to human response. The researchers noted that the load on the restraint system is less for bodies having more articulation. Thus, a solid wood block imposed the greatest load. Surprisingly, one stock dummy was surpassed by a sandbag, shaped like a dwarf, in simulating responses of the human body. Designers and manufacturers of dummies are working closely with NBS engineers in this research to improve dummy response.

The researchers examined current

front-seat models for dimensions and restraint system anchorages. Actual production seats from American cars were used in some of the Holloman tests.

Second Test Series

A second series of tests is now being conducted on the Daisy sled at Holloman, using human volunteers and improved anthropomorphic dummies. In this series, additional instrumentation was installed to measure the amount of energy absorbed by the legs of the volunteers during the simulated crash. These measurements show that the human legs absorb a significant amount of energy during the entire deceleration.[2] Because of the compressibility of the seats and of human viscera and the location of the seatbelt, the load to the restraint system lags the deceleration of the motor vehicle. However, the leg effort is in phase with the vehicle deceleration pulse, which means it is much more effective in restraining the occupant. The anthropomorphic dummies that are now available do not simulate this human leg effort.

The dummies used greatly resemble human bodies in physiognomy and articulation, having been developed to exhibit the same kinematics as a human being in a motor vehicle crash. These dummies are useful for research on other aspects of the effectiveness of a restraint system, such as evaluation of the degree of contact with the interior of the vehicle in actual car crashes. NBS, however, is concerned with developing the special dummies that are needed to test restraint systems for safety performance standards. Special dummies will be needed also for future evaluation of restraint systems for children and infants.

Other Developments

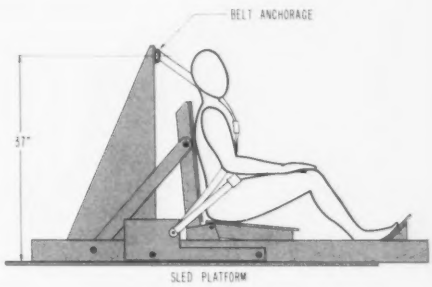
NBS is now developing an inexpensive crash recorder to indicate the peak impact force and its direction, and to measure simultaneously the maximum load on the restraint system. Such devices could be placed in fleet vehicles, such as State police cars, so that accident reports would yield new data on human tolerance levels.

The effect of human factors on motor vehicle safety is under study in other areas by the Office of Vehicle Systems Research.[3] For example, the effort required to apply the brake and to control the vehicle under partial brake failure is under investigation in research on braking systems. In tire research, the poor care of tires by the owner is under study to determine its effect on safety performance. Consideration of human factors in all three areas should ultimately lead to increased automotive safety.

TABLE 1. *Restraint system loading in Daisy test runs at 30 g deceleration*

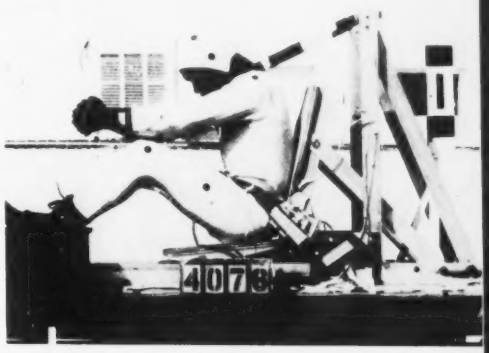
Sled "occupant" (normalized to same weight)	Load	
	pounds	newtons
Wood body block (no movable parts)	9760	43 400
Stock dummy, manufacturer "A"	8370	37 200
Sandbag	7530	33 500
Experimental sophisticated dummy, manufacturer "A"	6570	29 200
Sophisticated dummy, manufacturer "B"	5630	25 000
Human subject (extrapolated from lower-g data)	4250	18 900

An NBS experimental car seat used on the Daisy decelerating sled at the Holloman Air Force Base.

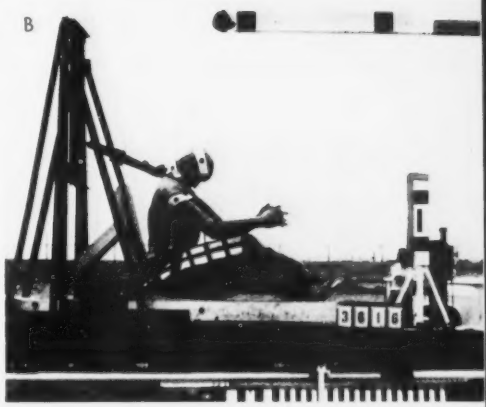


Various dummies and volunteers used in the Daisy decelerator were subjected to about 15-g deceleration. Shown are (A) an airman volunteer and (B) an anthropomorphic dummy.

A



B

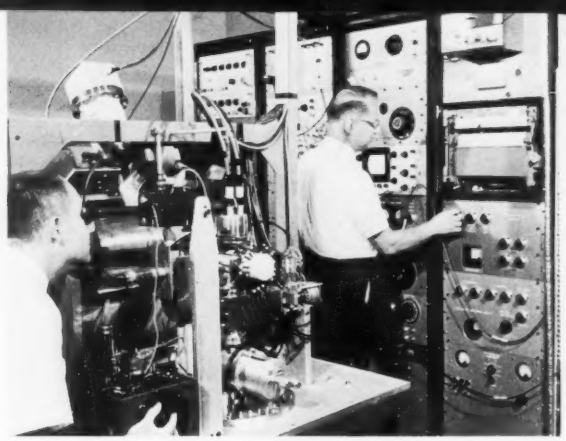


[1] Brown, P. J., **Human factors research in motor vehicle occupant restraint systems**, Proc. 9th Ann. Symp. on Human Factors in Electronics, Proc. IEEE (in press).

[2] Armstrong, R. W., Waters, H. P., and Stapp, J. P., **Human muscular restraint during sled deceleration**, Proc. 12th Stapp Car-Crash Conf., Soc. Automotive Engrs. (in press).

[3] **Automotive safety research expanded at NBS**, NBS Tech. News Bull. **51**, 246–248 (Nov. 1967).

Sublimation Rates of Heavy-Metal Negative Ions

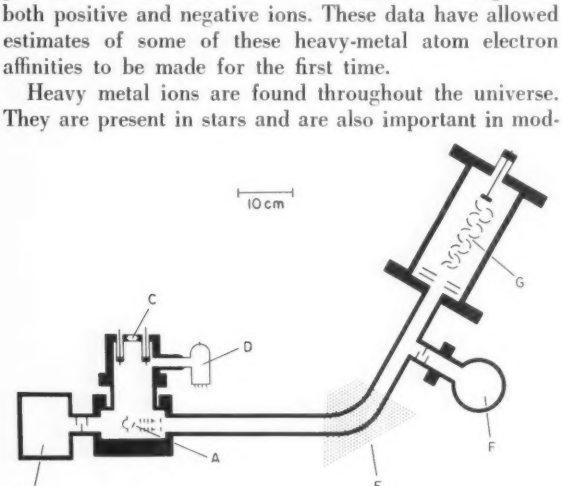


Joseph Fine (left) measures the sample surface temperature with an optical pyrometer while Milton D. Scheer adjusts the magnetic field to a point at which the ions are detected at the electron multiplier. The multiplier appears directly above the frame supporting the apparatus.

NEGATIVE-ION SUBLIMATION rates from some heavy metal surfaces have recently been determined at NBS. Subliming negative ions are very few in number, appearing in quantities about one-thousandth as great as the number of positive ions formed during the same process. Data obtained in these experiments enabled scientists Milton D. Scheer and Joseph Fine, of the NBS Institute for Materials Research, to establish that thermal equilibration is achieved on the subliming metal surface under the conditions of these experiments.[1]

Thermal equilibrium is attained when the amount of thermal energy lost by a metal during sublimation is equal to the total of the sublimation energies of all of the particles emitted by the subliming surface, plus the ionization energies of the atoms and negative ions. The total rate at which particles are emitted by the metal surface includes rates for neutral atoms (n), fewer positive ions (approximately $n \times 10^{-6}$), very few negative ions (approximately $n \times 10^{-9}$), and a very large number of free electrons (approximately $n \times 10^{9}$). The present studies [1, 2] produced extensive data on the sublimation energies of both positive and negative ions. These data have allowed estimates of some of these heavy-metal atom electron affinities to be made for the first time.

Heavy metal ions are found throughout the universe. They are present in stars and are also important in modern thermodynamic data compilations. They are used in implant studies in solid state physics. These ions are produced by heating a refractory metal within several hundred degrees of its melting point.



Apparatus for determining the sublimation rates of positive and negative ions includes a field-free ion source (A), an ion pump (B), a viewing port for source temperature measurements (C), a Bayard-Alpert pressure gage (D), a 60° magnetic sector (E), a second ion pump (F), and a 16-stage, Cu-Be electron multipler (G).

In the past, data on the sublimation of negative ions have been difficult to obtain because mass spectrometric instruments have not been sufficiently sensitive. Drs. Scheer and Fine, however, used a 16-stage, copper-beryllium electron multiplier together with nanosecond pulse circuitry for ion counting. With these devices, low ion yields could be detected, down to as few as one ion arriving every ten seconds at the first dynode of the electron multiplier.

The apparatus used in these experiments consists of a field-free, evacuated chamber in which the metal sample is heated above 2000 K. An electric field just beyond the heated metal source accelerates either the positive or negative ions to an energy of 4 kV and focuses them upon the entrance slit (100 μm) of a mass spectrometer. The ions are then mass analyzed by a 60° magnetic sector and finally focused onto an exit slit (250 μm) from which they are collected at the first dynode of the 16-stage Cu-Be electron multiplier. The variables measured in these experiments are the temperature of the subliming surface, the magnetic field strength, and the number of ions reaching the electron multiplier per unit time.

These quantities can be treated by the usual thermodynamic equations to obtain reliable estimates of the electron affinity and the atom and ion sublimation energies.

[1] Scheer, M. D., and Fine, J., **The positive and negative self-surface ionization of tantalum**, Proc. 4th Intern. Materials Symp., June 1968, Berkeley, Calif.

[2] Fine, J., and Scheer, M. D., **Positive and negative self-surface ionization** of molybdenum, J. Chem. Phys. **47**, 4267–4268 (1967); **Positive and negative self-surface ionization of tungsten and rhenium**, J. Chem. Phys. **46**, No. 10, 3998–4003 (May 1967); **Electron affinity of tungsten determined by its positive and negative self-surface ionization**, Phys. Rev. Letters **17**, No. 6, 283–284 (Aug. 1966); and **Surface ionization of niobium**, J. Chem. Phys. **42**, No. 10, 3645–3648 (May 1965).

NSRDS NEWS

The NSRDS was established in 1963 by the President's Office of Science and Technology to make critically evaluated data in the physical sciences available to science and technology on a national basis. The NSRDS is administered and coordinated by the National Bureau of Standards through the NBS Office of Standard Reference Data.

IUPAC Thermodynamic Tables Project

In the early 1960's, after canvassing a number of scientists and industrialists, the IUPAC Commission on Thermodynamics and Thermochemistry decided that a need existed for tables of the equilibrium thermodynamic properties of the liquid and gaseous phases of simple molecular structures. The Commission also decided that these tables should be based entirely upon experimental data. In 1964, therefore, the IUPAC Thermodynamic Tables Project was set up consisting of a Task Group, Working Panels, and a Project Centre.

Policy is the responsibility of the Task Group, while the preparation of tables rests with the Working Panels. There are Working Panels for Carbon Dioxide, the Atmospheric Gases (Oxygen, Nitrogen, Argon, and Air), the Aliphatic Hydrocarbons (Methane, Ethane, Propane, and Ethylene), the Quantum Fluids (Hydrogen and Helium), and so forth. These panels are small, having 3 to 6 members, each of whom is an expert in the Panel's field. In all, there are some 25 scientists from 8 countries—France, Germany, India, Japan, the Netherlands, U.K., U.S.A., and U.S.S.R. In addition, contributions are made by other scientists in these countries as well as by scientists in Belgium, Canada, Czechoslovakia, and Sweden.

Each Working Panel compiles a comprehensive bibliography, the principal component of which is provided by the NBS Cryogenic Data Center. A Panel critically surveys the available data from which tables can be prepared, and may recommend that more experimental data are needed. (The Project itself does not do any experimental work.)

Day-to-day administration of the Project is the responsibility of the Project Centre, located at the Imperial College of Science and Technology (University of London), Department of Chemical Engineering and Chemical Technology, Prince Consort Road, London, S.W.7, and is directed by S. Angus. The Centre is responsible for liaison and coordination of the work of the various Panel members and also for interesting experimenters in measuring the data that Panels decide are needed. Because the Centre is aware of current experimental activities in thermodynamics, it has acquired a secondary role as adviser to those planning programs.

The Project Centre finances are guaranteed by the U.K. Office for Scientific and Technical Information; contributions to its budget are also made by France, Sweden, and the U.S.S.R., but there is no central financial support for the Project as a whole.

The possibility of conflict between this Project and national projects in the same field is lessened by liaison between the Project Centre and the appropriate national bodies, such as the NBS Office of Standard Reference Data. These contacts are informal, except in the case of the U.S.S.R., where a Commission of the Academy of Sciences has been set up to ensure complete integration of the U.S.S.R. contribution with the IUPAC Project program.

No tables have as yet been issued. Of the 12 fluids currently being studied, all have needed further experimental work; however, the tables on carbon dioxide and oxygen are approaching their final form.

Molten Salts Data

NSRDS-NBS 15, *Molten Salts: Volume 1, Electrical Conductance, Density, and Viscosity Data* ($3), by G. J. Janz, F. W. Dampier, G. R. Lakshminarayanan, P. K. Lorenz, and R. P. T. Tomkins, has recently been published.[1] This work was undertaken to meet the need for a critical assessment of existing data for electrical conductance, density, and viscosity of inorganic compounds in the molten state. The compilation covers the scientific literature to December 1966. Recommended values were determined and are presented in the compilation as functions of temperature in the form of equations and tables. The results for 174 compounds as single-salt melts are reported in this work but none are reported for molten salt mixtures. Data are presented for fluorides, chlorides, bromides, iodides, carbonates, nitrites, nitrates, oxides, sulfides, sulfates, and a miscellaneous group. The selection of the best values (of the data for the calculations) was based on

continued

consideration of such factors as experimental techniques, the number of measurements, the temperature range, the deviations of the data from a fitted curve, and the reliability of previous work from any one center. In general, the data of each investigation were evaluated by fitting linear, quadratic, and exponential equations by the method of least squares. Usually the equation with the smallest standard deviation was selected as the best equation. In some cases, however, the data from several laboratories have been combined for arriving at a best value. Summary tables are also presented, as well as a list of more than 250 references and a compound index.

Microwave Spectral Tables

NBS Monograph 70, Volume IV, *Polyatomic Molecules Without Internal Rotation*[1] ($5.50), is the latest volume to be published in the 5-volume compilation of data entitled *Microwave Spectral Tables*, which was begun in 1953 by Paul F. Wacker, Marian S. Cord, Jean D. Petersen, Matthew S. Lojko, and Rudolph H. Haas are the authors of Volume IV. It contains data on the microwave spectra of 166 polyatomic molecules incapable of exhibiting internal rotation. These data are based upon a systematic search of the literature up to January 1961 and include some information of later date. This compilation contains measured frequencies, assigned molecular species, and assigned quantum numbers for about 14 000 spectral lines of polyatomic molecules without internal rotation as observed by coherent radiation techniques. Molecular data, such as rotational constants, dipole moments, and various coupling constants, determined by such techniques, are also tabulated. More than 1000 references are given for all included data. Indices according to empirical formula and according to chemical name are also provided. The other volumes are: Volume I, *Diatomic Molecules;* Volume II, *Line Strengths of Asymmetric Rotors;* Volume III, *Polyatomic Molecules With Internal Rotation* (in press), and Volume V, *Spectral Line Listing*, which contains a numerical listing of spectral lines given in Volumes I, III, and IV.

Atomic and Molecular Processes Bibliography

Compiled by the Atomic and Molecular Processes Information Center, Oak Ridge National Laboratory, an annotated bibliography of atomic and molecular processes for the period July-December 1967 has been published.[2] This is the eighth in a series of bibliographies by the Center under the joint sponsorship of the U.S. Atomic Energy Commission and the NBS Office of Standard Reference Date. Bibliographic sources consist of 80 scientific journals and 5 abstract journals. The references are classified into 14 major categories with appropriate subcategories, and are entered alphabetically in each category with their reactants or the atomic and molecular system of interest.

International Journal of Chemical Kinetics

A new international journal to cover the field of chemical kinetics is being published by Wiley-Interscience, with Sidney W. Benson and David M. Golden as editor and associate editor, respectively. This journal will be devoted to publishing those papers that explore the quantitative relationship between molecular structure and chemical reactivity. It will deal with inorganic, organic, and biochemical kinetics, and reaction mechanisms. In addition to original papers, the journal will accept Communications to the editor divided into two categories: Letters on preliminary results of immediate interest, and Comments on work of others or brief observations of unusual interest. One of the benefits that the editors will try to realize in the inauguration of the journal will be a more uniform set of standards for judging kinetics research. The decision to start this journal was made by editors and publishers after canvassing a large representative number of scientists actively engaged in kinetics research.

It is the preference of the editors that papers be published in the English language. Papers published in French and German require a complete and comprehensive synopsis in English. Manuscripts should be submitted to S. W. Benson, Stanford Research Institute, Menlo Park, Calif. 94025. Requests for subscriptions should be sent to Periodicals Department, John Wiley & Sons, 605 Third Avenue, New York, N.Y. 10016.

Raman Newsletter

The techniques of Raman spectroscopy have been considerably refined and their further development and application have been greatly stimulated by the introduction of the CW laser as a light source. At the meeting of the Atomic and Molecular Properties ad hoc Advisory Panel on Laser-Excited Raman Data of the NAS–NAE–NRC Office of Critical Tables (which also serves as an advisory Committee to the Office of Standard Reference Data), it was decided that an informal newsletter would be useful in quickly disseminating information about current developments in Raman spectroscopy. The first issue was published in November 1968. Initially, the *Raman Newsletter* is being sent to workers active in the Raman field. To continue to receive it, a reader must contribute to its contents at least once every eight months. Contributions from anywhere in the world are welcome; the editor prefers that all letters be written in English. Reference to the *Raman Newsletter* by name in the scientific literature is not permitted. Contributions to the Newsletter should be sent to P. R. Wakeling, Coordinating Editor, *Raman Newsletter*, Room 24-C 1500 Massachusetts Avenue, N.W., Washington, D.C 20005.

Thesaurus of Engineering and Scientific Terms

A new comprehensive reference work for engineers, scientists, and technical information specialists, *Thesaurus*

of Engineering and Scientific Terms,[3] is designed to lay the groundwork for compatible information systems in all technical disciplines. The *Thesaurus* provides the basis for effective retrieval by any engineer or scientist who is generally familiar with the subject area in which he is searching. The *Thesaurus* supplies the necessary bridge between the technical language used in published technical documents and the language of the searcher for information.

The book contains over 18 000 separate descriptors for use in indexing and retrieval and, in addition, some 5000 entries referring to one or more of the descriptors as preferred indexing terms. All areas of science and technology are covered including the engineering disciplines—mechanical, civil, electrical, chemical, and so on—physics, chemistry, mathematics, the life sciences including medicine and biology, the social sciences, economics, and military science.

This 696-page book was developed over a period of 2½ years as a joint project of the Engineers Joint Council and the U.S. Department of Defense. Some 300 engineers and scientists from government, industry, and education took part in the project. Code name for the joint effort was Project LEX, administered by the Office of Naval Research in cooperation with the Engineers Joint Council.

Warsaw Symposium on Numerical Data

The Polish Academy of Sciences and the Polish National Board for Quality Control and Measures are jointly sponsoring an International Symposium on Numerical Reference Data for Science and Technology to be held in Warsaw on August 29–30, 1969. This meeting immediately precedes the International Conference on Calorimetry and Thermodynamics also sponsored by the Polish Academy of Sciences.

The Symposium is a recognition by Poland of the importance of international collaboration in preparation and dissemination of reliable data for science and industry as advocated by CODATA. A special point of emphasis in the meeting will be data for various important industries. Papers will be by invitation. The Chairman of the Organizing Committee is Prof. A. Bylocki, Bureau M 6, ul. Electroalna 2, Warsaw 1, Skr. P–10, Poland.

[1] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.
[2] Available from the Atomic and Molecular Processes Information Center, Oak Ridge National Laboratory, P.O. Box Y, Oak Ridge, Tenn. 37831.
[3] Available from the Engineers Joint Council, 345 East 47th St., New York, N.Y. 10017: Hard cover, $25; flexible cover, $19.50.

STANDARDS AND CALIBRATION

GEORGIA AND MISSOURI RECEIVE STANDARDS

Georgia and Missouri became the latest States to receive sets of weights and measures standards under a program to replace the standards of all 50 States. The sets included standards of both the customary and metric measurement systems.

On Monday, October 21, Allen V. Astin, NBS Director, presented a set to Governor Lester Maddox of Georgia in a ceremony at the State Weights and Measures Laboratory in Forest Park.

On Tuesday, October 22, Malcolm W. Jensen, Chief of the NBS Office of Weights and Measures, presented a set to Missouri's Commissioner of Agriculture, Dexter D. Davis, at the State Weights and Measures Laboratory in Jefferson City.

STANDARD FREQUENCY AND TIME BROADCASTS

WWV—2.5, 5.0, 10.0, 15.0, 20.0, and 25.0 MHz
WWVH—2.5, 5.0, 10.0, and 15.0 MHz
WWVB—60 kHz

Radio stations WWV (Fort Collins, Colo.) and WWVH (Maui, Hawaii) broadcast signals that are kept in close agreement with the UT2 scale by making step adjustments of 100 ms as necessary. Each pulse indicates that the earth has rotated approximately 15 arcseconds about its axis since the previous one. The pulses occur at intervals that are longer than one second by 300 parts in 10^{10} due to an offset in carrier frequency coordinated by the Bureau International de l'Heure (BIH), Paris, France. Adjustments are made at 0000 UT on the first day of a month. *There will be no adjustment made on March 1, 1969.*

Radio station WWVB (Fort Collins, Colo.) broadcasts seconds pulses derived from the NBS Time Standard (NBS–III) with no offset. Step adjustments of 200 ms are made at 0000 UT on the first day of a month when necessary. BIH announces when such adjustments should be made in the scale to maintain the seconds pulses within about 100 ms of UT2. *There will be no adjustment made on March 1, 1969.*

CONFERENCE & PUBLICATION Briefs

SYMPOSIUM ON THE ELECTRONIC DENSITY OF STATES

The Electronic Density of States will be the subject of the 3rd Materials Research Symposium sponsored by the National Bureau of Standards. The Symposium will be held at the NBS Gaithersburg (Md.) site November 3–6, 1969.

By demonstrating the correlation of various experimental and theoretical techniques used in studying the electronic density of states, this Symposium hopes to encourage further interdisciplinary cooperation. It should stimulate in the participant a wider appreciation of the particular techniques outside his own specialty and thus lead to a more complete understanding of the materials of interest to him.

The program will encompass experimental and theoretical methods of probing the density of states of electrons and charged quasi-particles in solids and liquids. It will stress the points of agreement and disagreement among these various theories and experiments. Special attention will be given to the applications of the knowledge of the density of states to the understanding of materials properties.

Consisting of both invited and contributed papers, the Symposium will hold sessions on the following topics: Theory and experiment of one-electron density of states; spectrographic methods, including photoemission (x-ray and ultraviolet), ion neutralization, soft x-ray; disordered systems such as alloys, liquids, dirty semiconductors, amorphous systems; many-body effects; density of states at the Fermi energy from specific heat, magnetic susceptibility, and Knight shift measurements; superconducting tunneling; tails in semiconductors; and applications to materials properties.

A limited number of contributed papers are being accepted. Information on deadlines for abstracts as well as other program information may be obtained from the Program Chairman, L. H. Bennett, Room B150, Materials Building, National Bureau of Standards, Washington, D.C. 20234.

THERMAL EXPANSION SYMPOSIUM

A Symposium on Thermal Expansion of Solids, sponsored jointly by the Westinghouse Astronuclear Laboratory and NBS, was held at the Bureau's Gaithersburg (Md.) facilities on September 18–20, 1968. The purpose of the Symposium was to stimulate and encourage communication among those concerned with thermal expansion measurements and analysis, and thus to advance the state-of-the-art of this important field.

The program consisted of over 30 invited and contributed papers covering practically the entire spectrum of thermal expansion measurement technology. The Symposium was coordinated by R. K. Kirby of the Bureau and P. S. Gaal of the Westinghouse Astronuclear Laboratory.

The more than 100 attendees were welcomed by A. V. Astin, Director, NBS, and T. R. Young, Chief, Metrology Division, NBS. Highlights of the Symposium included talks by O. L. Anderson, Columbia University (a historical review of the theory of thermal expansivity); G. K. White, National Standards Laboratory, Australia (a description of recent measurements at low temperatures); R. O. Simmons, University of Illinois (a complete review of measurements by diffraction methods); and A. L. Bowman, Los Alamos Scientific Laboratory (a description of measurements at high temperatures with neutron diffraction).

Walter H. Esselman, Westinghouse Astronuclear Laboratory, gave the banquet address Wednesday evening, September 18, on the subject of nuclear space propulsion.

Considerable interest was expressed in holding a second symposium, probably early in 1970, and a Board of Directors was appointed to formulate plans for it.

The Symposium proceedings will be published by NBS. Copies will be available from the U.S. Government Printing Office, Washington, D.C. 20402.

OPERATIONS RESEARCH/TIME SHARING SYMPOSIUM

The National Bureau of Standards was host on October 29–31 to over 500 persons attending an Operations Research/Time Sharing Symposium, which was sponsored jointly by the Bureau, the Office of Naval Research, and the Washington Operations Research Council. This, the first symposium sponsored jointly by these organizations had as its theme operations research and computer innovation. The area is of special interest now because many innovations are coming about as a result of sharing computer time on-line and to make fuller use of the shared facilities. Emphasis was placed on time-sharing technology as a tool for decision making. Although specific hardware and software techniques were not emphasized in the Symposium sessions, provision was made for demonstrating current applications.

The Symposium opened Tuesday morning, October 29, with a keynote address by Maj. Gen. W. E. Carter, Deputy Assistant Secretary of Defense. He discussed trends in information systems for decision making, including systems using time-sharing techniques. The Department of Defense not only uses on-line systems, but has to allocate for new and advanced information systems far into the future. General Carter noted in particular that it is difficult for a manager to foresee all his needs.

Later, at the Symposium banquet, Eugene Fubini of the IBM Corporation discussed several problem areas of large on-line systems. He asserted that the computer industry and operations researchers should cooperate in overcoming some of the major problems.

The keynote address was followed by a tutorial session on time sharing—its fundamental concepts, its use in education, and future system trends. This served as an introduction to the content of sessions to follow.

The second session dealt with present applications for time sharing, from the pedestrian to the venturesome. A down-to-earth aspect of flying was described in a paper on planning airline gate facilities, while another paper described procedures for projecting five years in the future the consumption of groceries. Specialized business applications presented were of insurance agency performance analysis and of credit rating communication. Management gaming was described as a no-longer esoteric management technique.

Planned and potential applications for systems in which computers are used on-line was the subject of the third session. It was opened with a talk by Nicholas E. Golovin, recently of the President's Office of Science and Technology, on the status of computers and the evaluative function in government. Other papers delivered in this session dealt with the emerging use of data management systems in the Defense Department, the use of on-line computing systems in planning strategic defense, time sharing in educational simulation, and trends in displays for management.

Cost-benefit analyses of time sharing were presented in the second Wednesday session. Some of the analyses were nonspecific in application, such as those describing benefits to management and data managers from use of an on-line shared computer. Another cost/benefit analysis dealt with a specific application, on-line assistance in text editing and publishing.

The first Thursday session turned to potential solutions to special problems, some of them widespread: gaining acceptance of the shared computer as a new technological resource, and protecting privacy in the shared system. Another problem dealt with was the public policy issue resulting from the interdependence of the computing and communicating functions. Still others were the purely technical ones arising in developing resource-shared systems. The final session, which followed, consisted of a summary and panel discussion.

Among the demonstrations presented at the Symposium were those on time sharing as the retrieval system for multiply listed real estate, of an airline reservations system, and of a system for obtaining current stock quotations. In addition, the use of time-sharing systems for cost analysis and university/educational planning analysis was demonstrated.

Cochairmen of the Symposium were Hugh V. O'Neill, of the GE TEMPO Center for Advanced Study, and Donald W. King, of Westat Surveys, Inc.

Proceedings of this Symposium will be published by the Washington Operations Research Council and should be available in the first quarter of 1969.

SCHEDULED NBS-SPONSORED CONFERENCES

Each year NBS sponsors a number of conferences covering a broad range of topics in science and technology. The conferences listed below are either sponsored or cosponsored by NBS and will be held at the Bureau's Gaithersburg, Md., facility unless otherwise indicated. These conferences are open to all interested persons unless specifically noted. If no other address is given, inquiries should be sent to the person indicated below in care of Special Activities Section, Room A600, Administration Building, National Bureau of Standards, Washington, D.C. 20234.

1969 Particle Accelerator Conference. Mar. 5–7. Cosponsors: American Physical Society, Institute of Electrical and Electronics Engineers (NSG), National Science Foundation, U.S. Atomic Energy Commission. Contact: E. H. Eisenhower (NBS Center for Radiation Research). To be held at the Shoreham Hotel, Washington, D.C.

Thermodynamics of Bulk Polymers Symposium. Mar. 10–11. Contact: A. B. Bestul (NBS Polymers Division).

Symposium on Systems Analysis—The Application of Systems Analysis to Local Government Problem Solving. Mar. 10–14. Cosponsor: International City Managers Association. Contact: Robert Havlick, International City Managers Assoc., Suite 201, 1140 Connecticut Ave., Washington, D.C. 20036.

Fundamental Aspects of Dislocation Theory. Apr. 21–25. Contact: J. Simmons (NBS Metallurgy Division).

NRCA–NBS Joint Symposium on Roofing. Apr. 29–30. Cosponsor: National Roofing Contractors Association. Contact: T. H. Boone (NBS Building Research Division).

10th Symposium on Electron, Ion, and Laser Beam Technology. May 21–24. Cosponsors: University of Maryland, Institute for Electrical and Electronics Engineers (GED), American Vacuum Society. Contact: L. Marton (NBS).

NBS Measurement Seminars and Workshops 1968–

continued

BRIEFS *continued*

1969. Two- to five-day courses on measurement and calibration problems. Attendance limited. See October 1968 *Technical News Bulletin* for detailed information.

POLYMERS SYMPOSIUM

An invitational Symposium on Thermodynamic Properties of Bulk Polymers will be held Monday through Wednesday, March 10–12, 1969, at the National Bureau of Standards in Gaithersburg, Md. Sponsored by NBS, the Symposium is intended to present recent data on the thermodynamic properties of bulk polymers as well as a clearer theoretical understanding of the forces that determine their structures.

The Symposium will cover the following subject areas: Physical States (qualitative and quantitative characterization); Changes in Physical State (mechanisms and kinetics); Elasticity of Elastomers; Special Methods for Determining Thermodynamic Properties; State Properties and Their Derivatives for Common and Special Situations; and the Relationship between Thermodynamic and Molecular Properties. Included under Physical States will be discussions of the (partially) crystalline and amorphous states, the latter covering vitreous (plastic) and "liquid" (elastomeric) conditions. Changes in Physical State will encompass crystallization, melting glass transformation, and other transitions and relaxations.

Further information about the Symposium may be obtained from Dr. A. B. Bestul, Polymers Division, National Bureau of Standards, Washington, D.C. 20234.

INFRARED SPECTROSCOPY OF CARBOHYDRATES

Infrared Spectroscopy of Carbohydrates—A Review of the Literature, NBS Monograph 110[1] (21 pp.; 30 cents), is the first detailed survey of the literature on the infrared spectroscopy of carbohydrates. Prepared by R. Stuart Tipson, it is intended to answer the need to assemble and systematize information in this field.

The monograph discusses principles and instrumentation, sampling techniques, comparison of samples, interpretation of spectra, correlations for the finger-print region and beyond, and conformational studies. In addition, examples are given of the use of infrared spectra for qualitative and quantitative purposes, and in the determination of structure. Special techniques are briefly described, including plane-polarized radiation, attenuated total reflection, and Raman spectra.

ECCENTRICITY OF FLOOR LOADS APPLIED TO A BEARING WALL

NBS Building Science Series 14[1] (6 pp.; 15 cents) by D. Watstein and P. V. Johnson, reports some recently completed exploratory studies on the eccentricities of floor loads applied to a bearing wall by the Structural Clay Products Institute Research Fellowship at the National Bureau of Standards. The studies indicated that eccentricities can be measured using a specially designed stress-sensitive compressive strut calibrated under known loads.

Investigated were such parameters as thickness and rigidity of bearing materials, the intimacy of contact between the supporting structure and the flexural members, and the effect of a bond with the bedding materials on the eccentricity of the floor loads. The measurement of the eccentricity of the force at the base of a masonry wall subjected to an eccentrically applied load was also explored.

ACCELERATION DUE TO GRAVITY

NBS Monograph 107, *Acceleration Due to Gravity at the National Bureau of Standards*[1] (20 pp.; 25 cents), by D. R. Tate, reports on a determination of the absolute value of the acceleration due to gravity that was completed in June 1965 at NBS. This publication describes in detail the apparatus and the techniques employed and presents the summarized data from which the value was derived. The result was first published in the *Journal of Research of the National Bureau of Standards*.[2] The determination resulted in a value of 980.1018 cm/s^2 for a reference point on the first floor of the NBS Engineering Mechanics Building in Gaithersburg, Md.

QUANTITATIVE ELECTRON PROBE MICROANALYSIS

A seminar held at NBS in June 1967 critically examined the factors involved in quantitative electron probe microanalysis. The invited papers from this seminar are contained in NBS Spec. Publ. 298[1] (299 pp.; $3), edited by K. F. J. Heinrich.

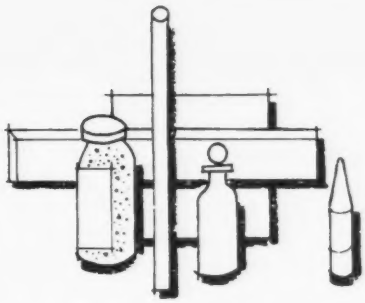
Major consideration is given to proposed methods for data evaluation and to requirements for further work in theory, in measurement, and in the preparation of standards. The papers cover corrections for the atomic number effects, for x-ray absorption, and for fluoresence by characteristic lines and the continuum. The various ways to derive a simplified model of the complex electron-target interaction are critically analyzed, and the accuracy of several proposed methods are compared by error histograms. Applications to analysis of biological specimens and to problems of stereometric analysis are discussed.

THERMAL CONDUCTIVITY CONFERENCE PROCEEDINGS

This volume, NBS Special Publication 302, *Thermal Conductivity—Proceedings of the Seventh Conference*,[1] edited by D. R. Flynn and B. A. Peavy, Jr. (801 pp.; $6.25), gives the full text or, in a few cases, the abstracts of 90 papers prepared for the Seventh Conference on Thermal Conductivity, which was held at NBS in November of 1967.

[1] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.
[2] J. Res. NBS **70C** (Engr. and Instr.), No. 2 (Apr.–June 1966).

STANDARD REFERENCE MATERIALS



Standard Reference Materials are well-characterized materials certified for chemical composition or for a particular physical or chemical property. These materials are disseminated by NBS to be used to calibrate and evaluate measuring instruments, methods, and systems or to produce scientific data that can be referred readily to a common base.

The National Bureau of Standards has issued three new heat-source calorimetry standards and a steelmaking alloy standard, and has renewed a low-alloy steel and a modular iron standard.[1]

Heat-Source Calorimetry Standards

Three new barium chromate-zirconium standards for calorimetry of gasless heat-source materials have been certified by NBS. Designated SRM's 1651, 1652, and 1653, they have nominal heating values of 350, 390, and 425 $cal \cdot g^{-1}$, respectively. These values are obtained when no air, oxygen, or nitrogen is in contact with the sample. To obtain reliable calorimetric values with the new standards, air should be excluded or purged from the reaction vessel by an inert gas.

The heating values were obtained calorimetrically by comparison with electrical energy measured in terms of the national standards of resistance, voltage, and time using a specially designed electrical heater and a small calorimeter submerged in an isothermal calorimeter jacket.[2] The heating values, using the value of the calorie defined as 4.184 joules, were:

SRM 1651—1460.0 ± 4.8 $J \cdot g^{-1}$ (348.9 ± 1.1 $cal \cdot g^{-1}$)
SRM 1652—1632.2 ± 7.3 $J \cdot g^{-1}$ (390.1 ± 1.7 $cal \cdot g^{-1}$)
SRM 1653—1762.0 ± 3.0 $J \cdot g^{-1}$ (421.1 ± 0.7 $cal \cdot g^{-1}$)

In 1963, NBS calibrated a batch of heat-source powder with respect to heating value as a tentative reference material for the Harry Diamond Laboratories. The new calorimetric standards are the outcome of the preparation of these earlier tentative reference materials. They will fill the need that has existed for several years in various agencies of the Department of Defense for heat-source powders that evolve a well-defined quantity of heat when used for special applications.

The heat evolved by some manufactured products is a critical factor in their use. Direct calorimetric tests of the heating value are made on samples selected from production runs and used for on-line production quality control. Reference heat-source materials similar to the production item and of known heating value permit calibration of a calorimeter by a process similar to that used to measure the production item. Thus, a material of known heating value can be introduced at intervals to verify the accuracy of data being obtained on production line materials.

The barium chromate-zirconium mixture from which the new standards were prepared was formulated by the Eureka Williams Co., Bloomington, Ill., from materials that met defined specifications.[3, 4] The mixed powders were agglomerated, to prevent segregation by material or by size.[5] The agglomerate was dried, screened, and separated into 2.4-kg segments, which were further separated into smaller units for safety in handling.

The calorimetric measurements on the materials were carried out by James T. Minor of the NBS Institute for Materials Research. The details of the calorimetric procedures will be published in the series of NBS publications dealing with Standard Reference Materials.

The new calorimetry standards are available, with a Certificate that includes safety precautions, in units weighing approximately 50 grams, for $50 per unit.[6]

Ferroniobium Standard

A ferroniobium standard reference material has been prepared at the request of manufacturers of steelmaking addition alloys and of Division F of ASTM Committee E–3 on Chemical Analysis of Metals. This ferroniobium standard, designated SRM 340, is issued with a Provisional Certificate of Analysis.

Niobium is added to high temperature alloys and corrosion-resistant stainless steels as a carbide stabilizer to improve high temperature characteristics; it is a constituent of a number of newer grades of high strength low-alloy steels in which it enhances hardenability.

The new standard is certified for niobium, tantalum, titanium, carbon, manganese, phosphorus, and silicon. It fills an important need of the steelmaking industry and of the ferro-alloy producers because these alloys are bought and sold on the basis of their contained content of the alloying constituent. Material for SRM 340 was furnished by the Electrometallurgical Corp., Division of Union Carbide Corp., Niagara Falls, N.Y. *continued*

REFERENCE *continued*

Supplied in the form of granules in units weighing approximately 100 grams, SRM 340 costs $40 per unit.[6]

Low-Alloy Steel Standard

The renewal of the low-alloy steel standard, SRM 36b, is issued with a Provisional Certificate of Analysis. This standard, a 2-percent chromium, 1-percent molybdenum steel first issued in 1941, is one of a series of low-alloy steel standards available from NBS.

The steel is representative of a grade widely used in tubular products for elevated temperatures, such as boiler tubes and pressure vessels. It is also of particular interest to power plant manufacturers.

As a control sample for analytical work, the elements carbon, manganese, phosphorus, sulfur, silicon, chromium, and molybdenum are of signal interest and these elements have been certified. The certificate also gives values for copper, nickel, and vanadium.

The material for SRM 36b was provided by the Lukens Steel Corporation, Coatesville, Pa.

Available in chip-form in units weighing approximately 150 grams, SRM 36b costs $28 per unit.[6]

Nodular Iron Standard

The renewal of the nodular iron standard, SRM 342a, provides an additional standard for analytical control calibration in the cast iron industry. First issued as SRM 342 in 1961 at the request of the American Foundrymen's Society, SRM 342a differs sufficiently in chemical composition from that of SRM 342 to make it a useful supplement to the older standard. Unusual properties, high strength with good ductility, and high modulus of elasticity of this iron-base alloy make it a popular material for a specialized segment of the metals industry. The Provisional Certificate of Analysis for SRM 342a includes values for total and graphitic carbon, manganese, phosphorus, sulfur, silicon, copper, nickel, chromium, titanium, and magnesium, the latter being the ingredient added to cast iron to produce the nodular structure.

The material for SRM 342a was prepared at the American Cast Iron Pipe Company, Birmingham, Ala.

In chip form, sized between 16 and 25 mesh sieves, SRM 342a is supplied in units of approximately 150 grams for $28 per unit.[6]

New Prices for Standards

New prices for the benzoic acid calorimetric standard, SRM 39i; for light-sensitive paper, SRM 700b; and for faded strips for calibrating light-sensitive paper, SRM 701b, were made effective November 1, 1968. The new prices—39i, $27; 700b, $35; and 701b, $150—reflect the current production costs of these materials.

The latest quarterly insert to *Standard Reference Materials: Catalog and Price List of Standard Materials Issued by the National Bureau of Standards*, NBS Misc. Publ. 260 (1968 ed.) is dated November 1, 1968, and reflects these price changes.[1]

[1] For a complete list of Standard Reference Materials available from NBS, see **Standard Reference Materials: Catalog and Price List of Standard Materials Issued by the National Bureau of Standards**, NBS Misc. Publ. 260 (1968 ed.) for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 45 cents. Quarterly insert sheets which update Misc. Publ. 260 are supplied to users on request.

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[6] These standards may be purchased for the price indicated from the Office of Standard Reference Materials, Rm. B308, Chemistry Bldg., National Bureau of Standards, Washington, D.C. 20234.

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Technical News Bulletin, Volume 53, No. 1, January 1969, 30 cents. Annual subscription: Domestic, $3; foreign, $4. Available on a 1-, 2-, or 3-year subscription basis.

Journal of Research of the National Bureau of Standards

Section A. Physics and Chemistry. Issued six times a year. Annual subscription: Domestic, $6; foreign, $7.25. Single copy, $1.

Section B. Mathematical Sciences. Issued quarterly. Annual subscription: Domestic, $2.25; foreign, $2.75. Single copy, 75 cents.

Section C. Engineering and Instrumentation. Issued quarterly. Annual subscription: Domestic, $2.75; foreign, $3.50. Single copy, 75 cents.

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